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by

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This report summarizes, for a military audience, work on seven research projects: (a) Target Handoff Techniques, (b) Tank Crew Measures of Effectiveness (MOE), (c) Fatigue Effects of CAV NAV Goggle Use, (d) Long Range Target Recognition, (e) Effects of Stress on Performance, (f) Symbology for Automated Graphic Displays, and (g) Suppression Research. There are separate reports for each of these seven areas. An eighth report briefly describes a technique for developing imagery for target handoff and target identification training.

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Technical Report TR-79-A15

FINAL REPORT: HUMAN FACTORS RESEARCH IN MILITARY ORGANIZATIONS AND SYSTEMS

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May 1979

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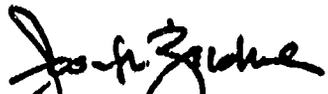
FOREWORD

This report summarizes the results of seven research efforts conducted in support of the US Army Research Institute for the Behavioral and Social Sciences (US/ARI) Field Unit at Fort Hood, Texas. Separate, more detailed reports describing the work in each of the six areas are being published concurrently. The results of the work in the seventh area was published earlier.

This research was conducted as the third year's effort under Contract DAHC19-75-C-0025 under the sponsorship of US/ARI. Administrative and logistical support was provided by the US/ARI Field Unit, Fort Hood, Texas, under the direction of Mr George Gividen. Dr. Charles Nystrom served as the Contracting Officer's Technical Representative (COTR). The purpose of the overall effort was to provide human factors support to the US/ARI Field Unit, Fort Hood, in seven specific areas: target handoff techniques, tank crew measures of effectiveness, fatigue effects of CAV NAV goggle use, long range target recognition, effects of stress on performance, symbology for automated graphic displays, and suppression research.

The overall research effort was under the direction of Dr. Albert L. Kubala, Team Chief, HumRRO Team-Fort Hood. The HumRRO Team is a unit of the Western Division of HumRRO. Dr. Howard H. McFann, Vice President, HumRRO, is Director of the Western Division and provides general supervision for all Division personnel. Ms. Nancy Lawson assisted in the acquisition of bibliographic materials and the production of typed manuscripts for all projects.



JOSEPH ZEIDNER
Technical Director

FINAL REPORT: HUMAN FACTORS RESEARCH IN MILITARY ORGANIZATIONS AND SYSTEMS

BRIEF

Requirement:

Both the accuracy and lethality as well as the variety of weapons in the arsenals of today's major powers has greatly increased during the period since the Korean Conflict. As a result, new tactics have been developed, and the wars of the future are not expected to be like those of the past. The US Army must be prepared to fight in conflicts where friendly forces are outnumbered, have doubtful air superiority, and are faced with the potential use of unconventional weapons. Human factors considerations in the conduct of this type of conflict are quite different than in the past. A requirement exists to determine just what these considerations are. This effort examined seven specific areas.

The objectives were:

- To develop techniques for low-cost experimental studies of target handoff in order to specify new procedures and specify requirements for new equipment.
- To investigate problems involved in designing valid and practical tank crew Measures of Effectiveness (MOE).
- To look at problems associated with wear of the AN/PVS-5 NVG.
- To evaluate recognition/identification performance of aviators using camouflaged targets.
- To review the literature on display symbology and examine the patterns of preference of naive subjects for alternative sets of symbols.
- To prepare a compilation of the literature on stresses likely to be encountered by combat soldiers.
- To relate the physical characteristics of ammunitions to subjective indices of suppression.

Procedure:

A staff member was assigned primary responsibility for each of the research areas. A significant portion of the time for several of the efforts was expended in the search for and accumulation of relevant information. Information was sought through the Defense Documentation Center (DDC), University of Texas libraries, HumRRO libraries in other locations, and through personal contacts. Reviews of the documentation are included as appropriate in each report. A considerable amount of time was also spent in the planning and execution of a number of field and laboratory studies.

Principal Findings:

- Target Handoff. Generally, intensive practice under simulated conditions results in improved performance. Again, under simulated conditions, training in recognition and identification was highly effective in improving performance in target acquisition, but did not affect performance in target handoff. Finally, a very effective technique was developed for the preparation of imagery of vehicles emplaced in terrain.

- Team Effectiveness. It was found that there were no generally acceptable definitions of either "team" or "effectiveness." Secondly, it was found that effectiveness scores derived from Table VIII results were of questionable validity and unknown reliability. However, regardless of the evaluation strategy chosen, it was felt that comprehensive evaluation of tank crew performance was beyond the capabilities of most units.

- Night Vision Goggles. While the NVG were well accepted for nighttime flight, there were several persistent problems reported by users relating to fatigue and discomfort. These problems were seen to decrease with experience, but did not disappear. Postflight performance tests showed that aviators who had worn the NVG showed decrements in behavior in response to errors, and evidence of fatigue. It was found that comfort was enhanced by raising the brow of the helmet in conjunction with a chinoup or counterweight.

- Long Range Target Recognition. There were no differences in either recognition or identification due to range when the vehicles were presented on either a uniform or a terrain background. Regardless of the background against which the targets were displayed, training was highly effective in reducing error rates. However, the number of trials to learning criterion was increased by displaying the camouflaged vehicles against terrain.

- Stress. The literature reviewed indicated that historically the rate of neuropsychiatric casualties in combat have declined. However, despite the knowledge that combat soldiers are confronted with multiple stressors, the amount of research concerned with the performance effects of stress has been minimal. Most of the work found had little relationship to the role of the soldier in combat.

- Symbology Extensive survey of the literature revealed that there is available a great variety of alternative symbology formats. However, before a format can be selected, there must be an effort to determine the necessary information requirements for a particular position. For Army tactical displays, this information should be gathered in experiments utilizing realistic battle scenarios. As a related effort, a study was designed to evaluate alternative symbol formats. The results showed that naive subjects generally preferred a pictorial type symbol over the traditional military alternatives.

• Suppressive Fire. There was no way to determine the relationship between the acoustic signatures and a subjective measure of suppression. On the other hand, kinetic energy appeared to be highly related to these ratings. It was determined that further research is needed to validate this finding and to explore the relationship between other physical variables and suppression.

CONTENTS

FINAL REPORT: HUMAN FACTORS RESEARCH IN MILITARY ORGANIZATIONS AND SYSTEMS

The research described in this report was conducted by the Human Resources Research Organization (HumRRO) under contract to the US Army Research Institute for the Behavioral and Social Sciences (US/ARI). The contract number was DAHC19-75-C-0025. The work described herein was conducted during the third year of the contract, from 12 May 1977 to 11 May 1978.

Research was accomplished on seven research problems specified in the Scope of Work for the third year. These were titled: (a) Target Handoff Techniques, (b) Tank Crew Measures of Effectiveness (MOE), (c) Fatigue Effects of CAV NAV Goggle Use, (d) Long Range Target Recognition, (e) Effects of Stress on Performance, (f) Symbology for Automated Graphic Displays, and (g) Suppression Research. Technical reports describing the work in six of these areas are being published separately. The work accomplished in the seventh area (Tank Crew Measures of Effectiveness) is described in the *Proceedings of the 19th Annual Conference of the Military Testing Association*. The titles of the reports have been changed somehwat from those shown in the Scope of Work. This was done primarily to make the titles more specific, and does not reflect a deviation from the objectives outlined.

Most of the work was performed at Fort Hood, Texas. Logistical support was provided by the ARI Field Unit, Fort Hood, and Headquarters, TRADOC Combined Arms Test Activity (TCATA). Personnel and equipment for field tests were provided by the Sixth US Cavalry Brigade (Air Combat) (6th ACCB). The imagery employed in the study of target handoff techniques was produced by a process developed by HumRRO scientists at Fort Bliss, Texas. A slide/tape program in target recognition was also developed at Fort Bliss.

Two problems were encountered. The first was an inability of TOE units at Fort Hood to fully support one of the projects. This was due to requirements for support of other activities of higher priority. The second was the weather. Inclement weather delayed the completion of the field work on two of the projects for several weeks. However, all of the work described in the Scope of Work was accomplished.

Bibliographic information on the reports submitted are presented at the end of this summary report. Brief summaries of the work accomplished in each of the areas are presented below.

FURTHER STUDY OF TARGET HANDOFF TECHNIQUES

Background and Problem

Ground observers can handoff (designate) ground targets to other units with minimal difficulty because the appearance of the terrain is similar, since in both instances, it is being viewed from the same perspective. It is, however, difficult for a scout helicopter to designate targets for attack helicopters. It is very difficult for air observers to handoff targets to ground units, and equally difficult for ground units to handoff targets to elements of air cavalry or tactical helicopter units. However, it is expected that target handoff will occur more frequently between elements of Army air. Hence, the research was focused at improving air-to-air techniques. Because of the basic similarity in sources of difficulty in all handoff (i.e., perspective differences), it is thought that there will be a high degree of transfer from the air-to-air situation to other handoff situations.

Procedures

A relatively sophisticated technology was evolved for the production of static imagery to be used in the simulation of handoff. This imagery was used together with improved hardware to study the behavior of individuals performing handoff. This imagery featured arrays of threat and friendly vehicles emplaced in terrain. A photo montage approach was used to provide this imagery. The results were judged as quite realistic. In addition, an effort was focused on the development of an 80-minute slide/tape program in long range target recognition/identification. A similar montage technique was used to develop imagery for the training. Research using these resources was concentrated around three major activities:

- Content analyses of the verbal interchange between individuals performing simulated handoffs.
- The evaluation of unguided practice as an avenue to improved handoff performance.
- The evaluation of the role of long range target identification skills in target handoff performance.

The first activity involved analyses of transcripts of simulated handoff obtained during the second year of the research. A number of hypotheses were proposed based on observation and review of the literature. These hypotheses guided the subsequent analyses.

Secondly, a study was designed to evaluate the role of unguided practice and long range target identification training on simulated handoff performance. Subjects for the study were 44 pairs of experienced aviators and scouts from the 6th ACCB, Fort Hood, Texas.

Results

The principal findings of this research were:

(a) The technology for producing imagery for the handoff simulation and the identification training has great potential for the development of low-cost training.

(b) General handoff practice was effective in improving performance under simulated conditions.

(c) The recognition/identification training was effective but did not enhance handoff performance.

(d) Each handoff situation was seen as probably being unique. If this were the case, then each would require its own set of rules.

A second small report (Foskett and Ton) was prepared as a supplement to the general target handoff report. This briefly describes the technology which was developed for preparing imagery for handoff simulation and long range target recognition/identification training. Subject to the availability of funds, a further effort will expand this technology to make it usable by Army aviation activities.

PROBLEMS IN MEASURING TEAM EFFECTIVENESS

Background and Problem

Most training research in the past has been focused on individual training in institutional settings. Yet, most combat activities have been, and will likely continue to be, performed by teams (e.g., squads, crews, etc.). Measures of Effectiveness (MOE) for teams are obviously needed to evaluate combat readiness. The objective of this research was to determine what set of MOE were currently being employed to evaluate tank crews and to determine what additional research was needed to insure a comprehensive evaluation capability.

Procedures

A review of the literature on the measurement of team effectiveness was conducted. Particular attention was devoted to any literature which dealt with MOE in armor operations. Personnel in the 1st Cavalry Division and the 2nd Armored Division were also interviewed. Information was sought on: (a) definitions of effectiveness, (b) definitions of team effectiveness, (c) the reliability of effectiveness measures, (d) possible team evaluation strategies, and (e) resource requirements for valid evaluations.

Results

The principal findings of this research were:

(a) There are no generally acceptable definitions of either the term "team" or the term "effectiveness."

(b) The only consistently employed MOE for tank crews is scores on Table VIII, and these scores are of questionable validity and unknown reliability.

(c) There is considerable disagreement on the most appropriate evaluation strategy for measuring effectiveness. For example, the use of both one-sided and two-sided tests have been advocated.

(d) Regardless of the evaluation strategies chosen, resource requirements for comprehensive evaluation of tank crews are beyond those available to most units.

FATIGUE EFFECTS FROM WEARING THE AN/PVS-5 NIGHT VISION GOGGLES

Background and Problem

Human factors problems related to use of the AN/PVS-5 Night Vision Goggles (NVG) by aviators have been mentioned in a general way in several reports. A frequently cited difficulty related to NVG wear over extended periods of time involves discomfort and fatigue resulting from the NVG's weight and poor mounting compatibility with the standard 3.4 pound helmet worn by aviators.

The overall research program was undertaken in an attempt to carefully define the fatigue problems incident to NVG use. More specifically, this present research was designed to identify common user complaints, to determine which visual and motor skills are most affected after lengthy NVG use, and to identify potential remedies to the discomfort, fatigue, and performance problems that were found.

Procedures

A questionnaire was designed to provide information regarding the usefulness of the NVG, the physiological locus and nature of any discomfort experienced by the user, and the ease with which the NVG could be positioned and adjusted. Twenty-one aviators and six motorcycle scouts completed the questionnaire upon returning from night maneuvers involving lengthy use of the NVG.

Visual and motor skill decrements resulting from NVG wear were determined from selected performance tests. These were administered to aviators before and after flights in which the NVG were used for long periods. A total of 34 individuals performed on the tests.

Several modifications to the helmet/goggle configuration suggested by users to relieve fatigue were constructed. Thirty aviators performed a head-turning exercise with different configurations in position, and rated each configuration along several dimensions afterward.

Results

The principal findings of this research were:

(a) The NVG were preferred over the naked eye for almost all nighttime maneuvers and tasks.

(b) Over 90% of users reported discomfort and fatigue problems related to NVG wear.

(c) Minor difficulties in NVG positioning and adjustment, and part of the discomfort reported, seem related to the interface of the NVG with the SPH-4 helmet.

(d) As experience with the NVG increased, users found them more useful for performing tasks and maneuvers, less rapidly fatiguing, and easier to position and adjust. However, even the most experienced users reported discomfort and fatigue problems.

(e) Eye-hand coordination decrements, lack of corrective behavior in response to errors, and evidence of prolonged physical exertion were apparent after lengthy NVG wear.

(f) Raising the brow of the SPH-4 helmet, along with adding a chincup or a counterweight to the helmet, were rated as promising physical modifications to relive discomfort.

LONG RANGE TARGET RECOGNITION AND IDENTIFICATION OF CAMOUFLAGED ARMORED VEHICLES

Background and Problem

Previous studies had revealed that potential targets can be positively identified at ranges of 3000 and 4000 meters under near optimum conditions employing the COBRA/TOW (XM65) weapons sight. However, further research was needed to fully examine the effects of degraded

viewing conditions on the ability of crewmen to identify targets. Degradation would be by camouflage, partial obscuration, textured background, etc. The following objectives were developed for the study:

- To determine whether AH crewmen who had received previous training in armored vehicle identification could recognize and identify camouflaged (pattern painted) armored vehicles when viewed against a textured background at standoff ranges of 3000 and 4000 meters.
- To determine whether AH crewmen who had received previous training in armored vehicle identification could recognize and identify camouflaged (pattern painted) armored vehicles when they were emplaced in a terrain model at scaled distances of 2500 and 3500 meters.
- To determine whether AH crewmen could be trained to identify camouflaged (pattern painted) armored vehicles at standoff ranges.

Procedures

Scale (1:87) models of armored vehicles pattern painted in the standard Army US summer and Europe verdant colors were presented to AH pilot/gunners at scale ranges from 2500 to 4000 meters. Two experiments were designed and carried out. The first study was concerned with viewing the painted vehicles against a uniformly green textured background. The second study examined observation of the vehicles while they were situated on a terrain model. The observers viewed the models through a 13X magnification optical aid (COBRA/TOW weapons sight (XM65)) situated in a static COBRA AH.

The experiments were designed to provide information on the pretraining recognition and identification capabilities of the pilots, their performance during training, and their posttest recognition and identification performance. The first experiment used scale models of five different armored vehicles, the second experiment used ten different armored vehicles. [illegible] additional vehicles (AMX-30 tank and PT-76 (Soviet light tank) were introduced during the posttest phase of the first experiment to test the reactions of the pilots to unfamiliar vehicles. The model vehicles were presented in five different views: right and left sides, right and left obliques, and front.

Results

The principal findings of this research were:

(a) Attack helicopter crewmen could recognize and identify pattern painted armored vehicles at scaled ranges of 3000 and 4000 meters when

viewed against a uniformly colored textured background. Pretraining identification scores averaged 62% and rose to 96% and 98.6% during the training and posttest phases.

(b) Attack helicopter crewmen could recognize and identify pattern painted armored vehicles which were positioned on a terrain model at scaled distances of 2500 and 3000 meters. Pretraining identification scores averaged 46.5% and rose to 79% and 90% during the training and posttest phases.

(c) Target view was significantly related to recognition and identification performance. The front view degrades performance more than any of the five target views.

(d) The addition of camouflage patterns to the armored vehicle increases the number of learning trials needed to reach the learning criterion as established in these studies for recognition and identification performance.

A REVIEW OF SELECTED LITERATURE ON STRESSES AFFECTING SOLDIERS IN COMBAT

Background and Problem

Army authorities have long been concerned about stress and its effects on human behavior and mission accomplishment. Psychologists and psychiatrists have typically been concerned only with "combat stress." Most other investigators have also examined the effects of single stressors, such as heat, cold, or confinement. However, the stresses faced by the soldier in combat are many, and most likely act in combination rather than singly. This review was initiated as an attempt to place the various stressors in proper perspective; that is, to present the "big picture." It was felt that a single report which consolidated the major findings concerning the various stressors should reveal the gaps in our knowledge concerning the relationship between stress and performance, and thereby, indicate directions for future research.

Procedures

Relevant literature was sought from a variety of sources. Searches employing several different combinations of key words were conducted through the Defense Documentation Center. Other materials were sought through personal contacts and searches in a large university library. The bibliographies or reference sections of every document obtained were also scanned in an effort to locate additional relevant literature. Literature reviews or bibliographies on stress were sought in particular.

The literature obtained was categorized into that dealing with: (a) the history of the problem in the US military, (b) stress concepts, (c) the extent of the stress problem, (d) stresses affecting soldiers in combat, and (e) effects of stress on performance. A report was written which discusses the literature in each of the five categories listed above. Recommendations for further research were made.

Results

The principal findings of this research were:

(a) Neuropsychiatric casualties were a major problem in WWII, a smaller problem in Korea, and a comparatively minor problem in Vietnam.

(b) A multitude of both physiological and psychological stressors confront the soldier in combat.

(c) Research on the performance effects of stress has been minimal, and the results contain apparent inconsistencies. Much of this work is probably not relevant to the combat situation.

(d) Wounding rates, cumulative time in combat, and frustrations resulting from a lack of purposeful activity have consistently been associated with increases in combat exhaustion rates.

STUDY OF SYMBOLOGY FOR AUTOMATED GRAPHIC DISPLAYS

Background and Problem

The Army has recently expressed some dissatisfaction with the symbology currently used in tactical displays. These displays utilize cathode ray type computer-generated displays of the battlefield situation. The task of perceiving symbology and abstracting friend and foe information is difficult. This problem is compounded by the increased speed and amount of incoming data. As a consequence, it is necessary to either simplify the symbology so that it provides more meaningful information, or to provide separate displays to users with different information requirements.

This study was undertaken to review the symbology literature in order to pinpoint the cognitive demands required under various coding procedures. This information could then be used to facilitate the operator's information processing capacities and limitations, the extent to which different symbols are needed, and to estimate the amount of symbology that can be comprehended in a single presentation.

Procedures

The major effort of this study was a literature review of tactical operations systems, and automated graphic displays of symbols. This survey was intended to ascertain the more prominent and essential information requirements of tactical commanders, and the user capabilities and limitations in processing various types of computer-displayed symbologies.

In addition, a study of symbol preferences for some 24 common military units and activities was done using 25 relatively naive subjects to rank four symbols supposedly representing each of the situations.

Results

The principal findings of this research were:

(a) At present, the Army does not have a definitive list of minimal information requirements for each of the various tasks performed by users of computer-generated graphic displays.

(b) There appears to be available several alternative symbologies to either supplement or replace the current military symbols in use.

(c) Naive subjects, in an oversimplified situation at least, appear to prefer more pictorial type symbols.

(d) Much further research with alternative symbologies needs to be conducted in realistic battle-simulated scenarios in order to find what capabilities and limitations exist.

A FURTHER LOOK AT THE PREDICTION OF WEAPONS EFFECTIVENESS IN SUPPRESSIVE FIRE

Background and Problem

A field study conducted in the early 1970s produced psychological ratings of "perceived dangerousness" of a series of small arms fire events. A behaviorally anchored Suppression Index (SI) was also derived from a similar set of small arms fire events. It was concluded that the psychological scales were based almost entirely on the raters' reactions to the noises produced by the passing projectiles. However, no data on the acoustic signatures of the weapons employed were obtained at the time. The objectives of this research was to determine whether data on

the acoustic signatures of the projectiles were available, and if so, what aspect(s) of these signatures were related to the psychological scales.

Procedures

A review of the literature was conducted in an effort to locate data on the acoustic signatures of small arms projectiles. Personal contacts were also made with a variety of agencies involved in weapons testing and personnel safety. Exponential curves were fit to the available data for predicting each of the psychological scales from the kinetic energy of the projectiles.

Results

The principal findings of this research were:

(a) Data on the acoustic signatures of projectiles down range from the weapon are extremely limited, and are not complete enough to be of any value in determining the relationship between signatures and the psychologically-derived Suppression Index and perceived dangerousness ratings.

(b) Kinetic energy, which is believed to be closely related to the perceived loudness of passing projectiles, appears to account for nearly 100% of the variance between weapons on both the Suppression Index and the perceived dangerousness ratings.

(c) Further research is needed to validate the findings relative to kinetic energy, and to better establish the mathematical relationship between miss distance, rate of fire, and psychological scales such as the Suppression Index.

Bibliographic Information

The reports summarized can be identified separately by the following information:

Chastain, G. D., Ton, W. H., and Kubala, A. L. Fatigue Effects of Wearing the AN/PVS-5 Night Vision Goggles, FR-WD-TX-78-3, Human Resources Research Organization, Alexandria, Virginia, May 1978. Published as Army Research Institute TR-79-A16, 1979.

Foskett, R. J. and Ton, W. H. Development of a Photo Montage Technique for Simulation of Tactical Situations, FR-WD-TX-78-9, Human Resources Research Organization, Alexandria, Virginia, May 1978. Published as Army Research Institute TR-79-A17, 1979.

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Kubala, A. L. "Problems in Measuring Team Effectiveness," in Proceedings of the 19th Annual Conference of the Military Testing Association, San Antonio, Texas, 17-21 October 1977. (Also published as HumRRO Professional Paper 2-78, January 1978.)

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Ton, W. H., Hemingway, P. W., and Chastain, G. D. Further Study of Target Handoff Techniques, FR-WD-TX-78-5, Human Resources Research Organization, Alexandria, Virginia, May 1978. Published as Army Research Institute TR-79-A12, 1979.

Warnick, W. L., Chastain, G. D., and Ton, W. H. Long Range Target Recognition and Identification of Camouflaged Armored Vehicles, FR-WD-TX-78-7, Human Resources Research Organization, Alexandria, Virginia, May 1978. Published as Army Research Institute TR-79-A13, 1979.